MASTER

XV

Average sunshine, distance from coast and height above sea level

Introduction. From the study of maps showing isopleths of average daily sunshine it can be seen that the averages are highest near the coasts, especially the south coast, and also that there is reduced sunshine at high levels. An empirical formula, based on these concepts was therefore sought.

Method. Triple regression equations were computed for annual and seasonal sunshine, using 25 representative stations in England and Wales against:

1. Distance from nearest coast in tens of miles
2. Distance from south coast in tens of miles
3. Height above sea level in hundreds of feet

The results were:

Winter Sun (Dec.-Feb.)	$= 2.25 - 0.03C_N - 0.02C_s - 0.04H$	hrs/day
Spring Sun (Mar.-May)	$= 5.86 - 0.08C_N - 0.04C_s - 0.05H$	hrs/day
Summer Sun (June-Aug.)	$= 6.99 - 0.06C_N - 0.06C_s - 0.04H$	hrs/day
Autumn Sun (Sept.-Nov.)	$= 3.82 - 0.04C_N - 0.03C_s - 0.04H$	hrs/day
Annual Sun	$= 4.78 - 0.04C_N - 0.04C_s - 0.05H$	hrs/day

where C_N = distance from nearest coast in tens of miles
C_s = distance from south coast in tens of miles
H = height above sea level in hundreds of feet

Check. Using the above equations, the seasonal and annual average sunshine were calculated for all stations in England and Wales appearing in the publication "Averages of Bright Sunshine for Great Britain and Northern Ireland, 1921-50". Those stations where sunshine was obstructed or reduced by smoke were omitted. The figures obtained were then compared with the standard period averages. This comparison suggested that the constants in the equations should be adjusted slightly to obtain a better fit.

The adjustments made were

Winter 2.25 to 2.19 Summer 6.99 to 7.14
Spring 5.86 to 5.84 Autumn 3.82 (no change)
Annual 4.78 to 4.77

The averages were then recalculated and the final distribution of errors was as follows:

	Calculated Sunshine - Average Sunshine															
	-0.6	-0.5	-0.4	-0.3	-0.2	-0.1	0.0	+0.1	+0.2	+0.3	+0.4	+0.5	+0.6	+0.7	+0.8	Total
Winter	1	2	2	4	17	26	35	20	11	2	4	3				127
%	0.8	1.6	1.6	3.1	13.4	20.5	27.6	15.7	8.7	1.6	3.1	2.4				
Spring	2	1	2	11	15	23	29	17	12	10	6	1	1	1		131
%	1.5	0.8	1.5	8.4	11.4	17.6	22.1	13.0	9.2	7.6	4.6	0.8	0.8	0.8		
Summer	3	1	8	13	14	24	17	8	15	12	7	3	4	1	1	131
%	2.3	0.8	6.1	9.9	10.7	18.3	13.0	6.1	11.4	9.2	5.3	2.3	3.1	0.8	0.8	
Autumn	1	2	2	5	14	22	33	24	12	11	4					130
%	0.8	1.5	1.5	3.8	10.8	16.9	25.4	18.5	9.2	8.5	3.1					
Annual	2	1	2	9	15	18	29	22	19	10	4					131
%	1.5	0.8	1.5	6.9	11.5	13.7	22.1	16.8	14.5	7.6	3.1					

From these figures it was found that a large percentage of the calculated sunshine hours were within ± 0.3 hrs. of the average sunshine recorded at the individual stations. The actual percentages within these limits were

Winter	90.6%	Summer	78.6%
Spring	89.3%	Autumn	93.1%

Annual 93.1%

The summer figure is low, but if the limits are extended to ± 0.4, then 90.0% are included. Furthermore 0.4 hours is only about 6% of the summer average sunshine.

Summary. The average daily sunshine at an unobstructed site in England or Wales can, in the great majority of cases be calculated to within ± 0.3 hrs/day by the use of the following formulae

$$\text{Winter Sun} = 2.19 - 0.03C_N - 0.02C_s - 0.04H \text{ hrs/day}$$
$$\text{Spring Sun} = 5.84 - 0.08C_N - 0.04C_s - 0.05H \text{ hrs/day}$$
$$\text{Summer Sun} = 7.14 - 0.06C_N - 0.06C_s - 0.04H \text{ hrs/day}$$
$$\text{Autumn Sun} = 3.82 - 0.04C_N - 0.03C_s - 0.04H \text{ hrs/day}$$
$$\text{Annual Sun} = 4.77 - 0.04C_N - 0.04C_s - 0.05H \text{ hrs/day}$$

where C_N = distance from nearest coast in tens of miles
C^s = distance from south coast in tens of miles
H^s = height above sea level in hundreds of feet

Examples

Withypool in Somerset is 10 miles from the nearest coast (which lies to the north) and 60 miles from the south coast. It is 1100 feet above sea level.

To obtain an estimate of the annual average sunshine at a place near Withypool which is unobstructed by either buildings or trees, and is not in the shadow of any neighbouring hill for any great length of time during the day, we can substitute in the above equations as follows:

$$C_N = 1 \qquad C_s = 6 \qquad H = 11$$

Therefore, Average annual sunshine

$$= 4.77 - (0.04 \times 1) - (0.04 \times 6) - (0.05 \times 11)$$
$$= 4.77 - 0.04 - 0.24 - 0.55$$
$$= 4.77 - 0.83$$
$$= 3.9 \text{ hours/day}$$

Similar substitutions may be made in the other equations; this process can be repeated for any other place in England and Wales, obtaining results like the following:-

Place	Dist. from nearest coast in 10's of miles	Dist. from south coast in 10's of miles	Ht. above sea level in 100's of feet	Calculated				
				Winter Sun hrs/day	Spring Sun hrs/day	Summer Sun hrs/day	Autumn Sun hrs/day	Annual Sun hrs/day
Withypool, Som.	1	6	11	1.6	5.0	6.3	3.2	3.9
Kidderminster, Worcs.	8	12	2	1.6	4.6	5.9	3.1	3.9
Mablethorpe, Linc.	0	18	0	1.8	5.1	6.1	3.3	4.1

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